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YELLOW RUST OF WHEAT - SURVEY OF SENSITIVITY TO DMI FUNGICIDES IN 1997

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by

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Abstract

An investigation of the sensitivity of *Puccinia striiformis* (yellow rust of wheat) to DMI fungicides in 1997 provided clear evidence of a recent shift towards insensitivity.

Objectives

The objectives of the study were to determine whether the sensitivity of yellow rust to DMI fungicides has declined since 1990 and to confirm cross-insensitivity between older and more recent DMIs.

Background

Control of yellow rust of wheat (*Puccinia striiformis*) on susceptible varieties is heavily dependent upon DMI fungicides. Despite the advent of a new generation of fungicides with novel modes of action, DMIs are likely to continue as vital components of fungicide mixtures and programmes where rust control is required. Any decline in effectiveness of the DMIs due to the development of resistance in the yellow rust pathogen would therefore have serious consequences for farmers.

In 1997 and 1998 there were widespread epidemics of yellow rust on the highly susceptible and popular variety Brigadier. The capacity of fungicides to control the disease was severely tested and in some instances control was less effective than farmers might have expected from previous experience. Poor control could frequently be attributed to incorrect fungicide timing or excessively low dose rates. However, the question remained as to whether reduced sensitivity may have contributed to control problems.

Baseline information on yellow rust sensitivity was obtained at NIAB in an earlier investigation (Barnard, 1992; Bayles & Barnard 1992; Bayles & Stigwood, 1994). As part of this initial project, a bioassay was developed for screening pathogen isolates for sensitivity to triazole and morpholine fungicides and the baseline variation in the sensitivity of isolates was described. Comparison of isolates collected from the early 1960s onwards gave no evidence that sensitivity had declined with time. Critical reference isolates displaying different levels of sensitivity were identified for use in future tests and have been maintained in long term storage. There has been no comprehensive survey of yellow rust sensitivity to fungicides since 1990.

Materials and Methods

Sensitivity to triadimenol

60 isolates of *Puccinia striiformis* (yellow rust of wheat), collected by the United Kingdom Cerel Pathogen Virulence Survey (UKCPVS) during 1997 (55 isolates) and the early part of 1998 (5 isolates) were tested for sensitivity to the DMI fungicide triadimenol. 51 isolates were collected from farm crops and the remaining nine from

trials. More than half of the isolates came from the highly susceptible variety Brigadier and all possessed virulence for the resistance gene Yr17, present in this and related varieties. In this respect they were representative of the larger set tested for pathogenicity by the UKCPVS in 1997, some 99% of which were virulent on Yr17 (Bayles and Stigwood, 1998). Two reference isolates, carried forward from the earlier survey of yellow rust insensitivity, were included in each test. These were WYR 83/62, representing the middle of the sensitivity range prior to 1991 and WYR 90/20, representing the insensitive end of the range.

Test methods were similar to those described by Barnard (1992). Seedlings of the universally susceptible variety Vuka were grown in 5cm square plastic pots in a spore-proof glasshouse. 15 seeds were sown per pot, being thinned to 10 seedlings after emergence. When the first leaf was expanded (9-10 days after sowing) seedlings were sprayed with triadimenol by means of a field application simulator sprayer delivering 200 l/ha. The following rates were applied:

Triadimenol:	113.00 mg a.i./ l	(1/5 field rate)
	62.50 mg a.i./l	(1/10 field rate)
	31.25 mg a.i./ l	(1/20 field rate)
	nil	

Twenty four hours after spraying, seedlings were inoculated with uredospores of *P. striiformis* isolates using a mixture of 1 part spores to 19 parts talc applied by a rotary spore inoculator. Each test comprised the two reference isolates and a number of test isolates, with three replicate pots of each isolate / fungicide rate combination. Following inoculation, pots were sealed in large bags containing a small quantity of water and allowed to stand in a refrigerator at 7°C for 24 hours. They were then transferred to a controlled environment room under a regime of 16 hours light at 18°C and 8 hours dark at 11°C.

Yellow rust infection was assessed 15 days after inoculation using a 0-10 scale based on the proportion of the leaf bearing sporulating pustules (10 being equivalent to 100%). For each isolate, the infection score at each fungicide rate was expressed as a percentage of the score at nil fungicide and an ED_{50} value determined. A resistance factor, 'R factor' was calculated by dividing the ED_{50} of the test isolate by the ED_{50} of the reference isolate WYR 83/62. The ED_{50} value and R factor were adopted in preference to the insensitivity value 'D' used in the earlier study in order to improve the precision and repeatability of test results ('D' being based on a single dose rate whereas ED50 is based on a range of dose rates). The use of a common reference isolate ensured that valid comparisons could be made between the two studies.

Cross-insensitivity between triadimenol and epoxiconazole

Ten of the isolates tested for sensitivity to triadimenol, including the two reference isolates, were also tested for sensitivity to epoxiconazole, using the following fungicide rates:

Epoxiconazole:	15.62 mg a.i./ l	(1/40 field rate)
	7.81 mg a.i./l	(1/80 field rate)
	3.90 mg a.i./ l	(1/160 field rate)
	nil	

ED_{50} values were estimated for each isolate and compared with the corresponding values for triadimenol sensitivity.

Results

Sensitivity to triadimenol

Figure 1 shows the distribution of triadimenol R factors for isolates in the current study. For comparison, the distribution of triadimenol insensitivity values ('D') for isolates in the earlier survey are shown in Figure 2 (Barnard 1992).

In the 1960 - 1990 period, isolate 83/62 represented a mid point in the sensitivity range, with 58% of isolates being more sensitive (negative D values) and 42% less sensitive (positive D values). Isolate 90/20 was located towards the less sensitive end of the range, with only 7 isolates (2%) having higher D values. In contrast, the 1997 results indicate that the vast majority of isolates (83%) are now less sensitive than isolate 83/62, with a substantial proportion (54%) being less sensitive than 90/20.

This is evidence of a shift in sensitivity between the 1960-1990 period and 1997.

Cross-insensitivity between triadimenol and epoxiconazole

Figure 3 shows the relationship between Log ED_{50} values for triadimenol and epoxiconazole. Overall, ED_{50} values were lower for epoxiconazole (range 2.78 - 8.22 mg/l) than for triadimenol (range 7.59 - 276.00 mg/l), a reflection of the higher intrinsic activity of epoxiconazole. Taking the reference isolate 83/62 as a baseline, there was a marked tendency for isolates with increased ED_{50} values for triadimenol to have increased ED_{50} values for epoxiconazole. The correlation coefficient, $r = 0.629$, was significant at the $P = 0.1$ level and fell only just below the value required for significance at the $P = 0.05$ level. Given the small number of isolates tested, these results are consistent with the expectation that cross-insensitivity exists between the two DMI fungicides.

Discussion

The results of the 1997/98 survey demonstrate clearly that there has been a shift towards insensitivity to DMI fungicides in the wheat yellow rust population.

This shift took place during a period when the highly susceptible variety Brigadier was being grown on around 20% of the national wheat acreage. Weather conditions in 1997

and 1998 were generally favourable for yellow rust development, but often unsuitable for spraying operations at critical timings. The combination of varietal susceptibility and weather conditions, together with a tendency for fungicides to be used at rates well below those recommended, resulted in widespread yellow rust infection and inadequate control. In response to the high disease risk, DMIs were used repeatedly in many crops, starting with seed dressings and followed by foliar applications. On theoretical grounds, prolonged exposure to a fungicide is generally believed to increase selection for insensitivity and may well have contributed to the shift observed here.

Although there have been no confirmed cases of insensitivity causing failure of yellow rust control in the field, it is clearly important that every effort should be made to halt the sensitivity shift. Appropriate anti-resistance measures include growing resistant varieties, following the principles of variety diversification and spraying at the first signs of infection using adequate dose rates. Repeated applications of DMIs alone should be avoided by using co-formulations, recommended tank-mixes or sequences of sprays which bring together different modes of action effective against yellow rust (FRAG-UK, in press).

References

Barnard E G (1992). Fungicide insensitivity in yellow rust of wheat and barley. HGCA Project Report No. 55;

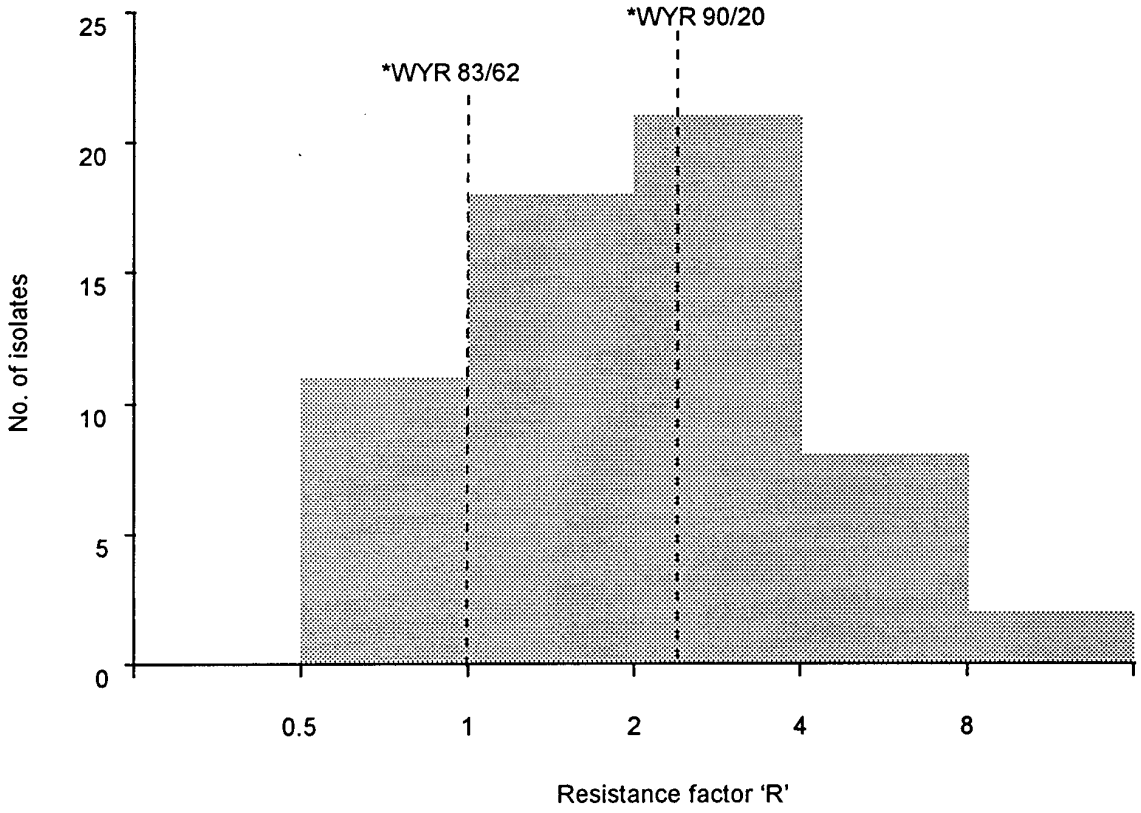
Bayles R A, Barnard E G & Stigwood P L (1993). Fungicide sensitivity in yellow rust of wheat (*Puccinia striiformis*). *Proceedings Brighton Crop Protection Conference* 1992, Vol I, 165-170.

Bayles, R A, Stigwood P L & Barnard E G (1994). Sensitivity to morpholine fungicides in yellow rust of wheat (*Puccinia striiformis*). In *Fungicide Resistance*. BCPC Monograph No 60, 309-314.

Bayles, R A & Stigwood P L (1998). Yellow Rust of Wheat. *United Kingdom Cereal Pathogen Virulence Survey Annual Report* for 1997, 23-29.

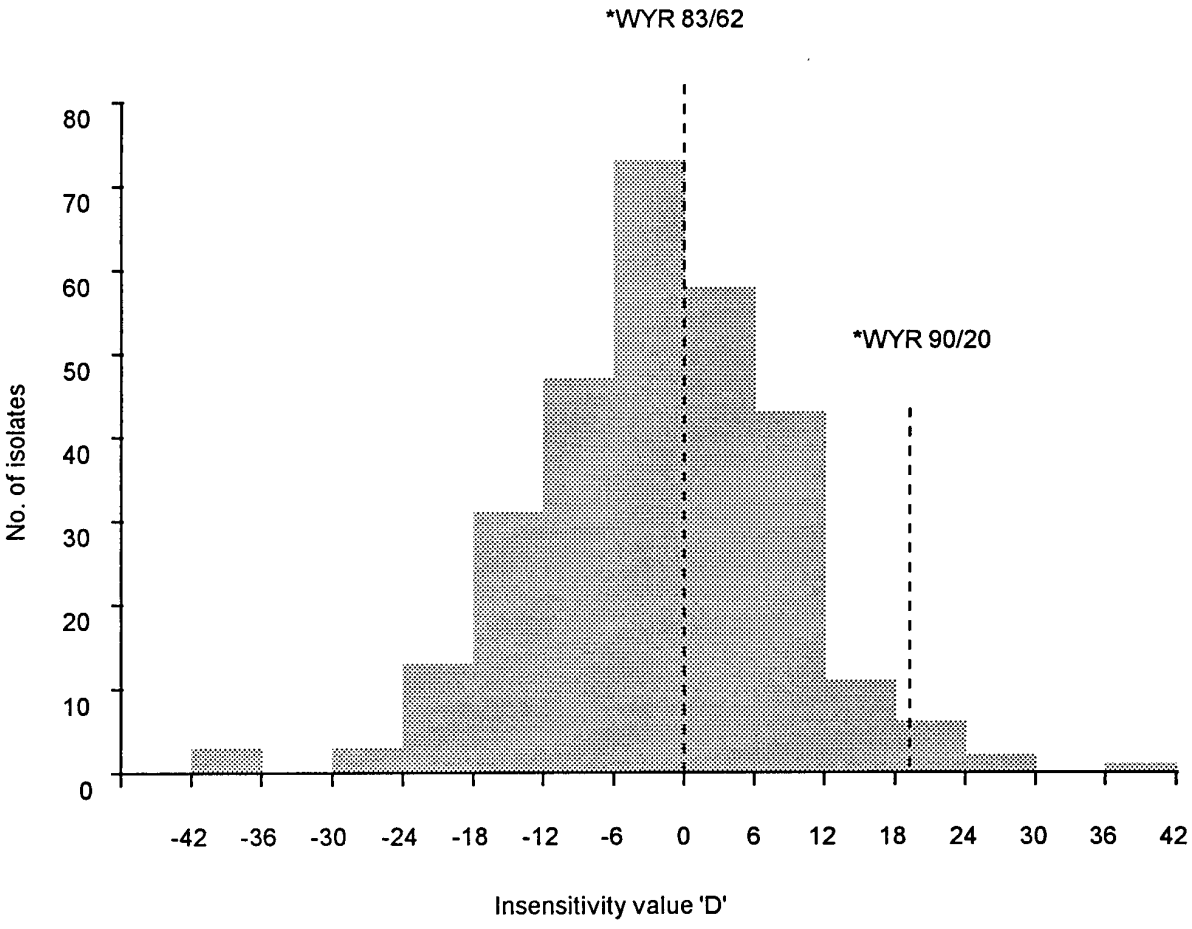
FRAG-UK (in press). Fungicide resistance in cereal pathogens. 2nd edition. Published H-GCA.

Figure 1. Frequency distribution of R factors for insensitivity to triadimenol for 60 isolates of *Puccinia striiformis* collected in 1997 and 1998



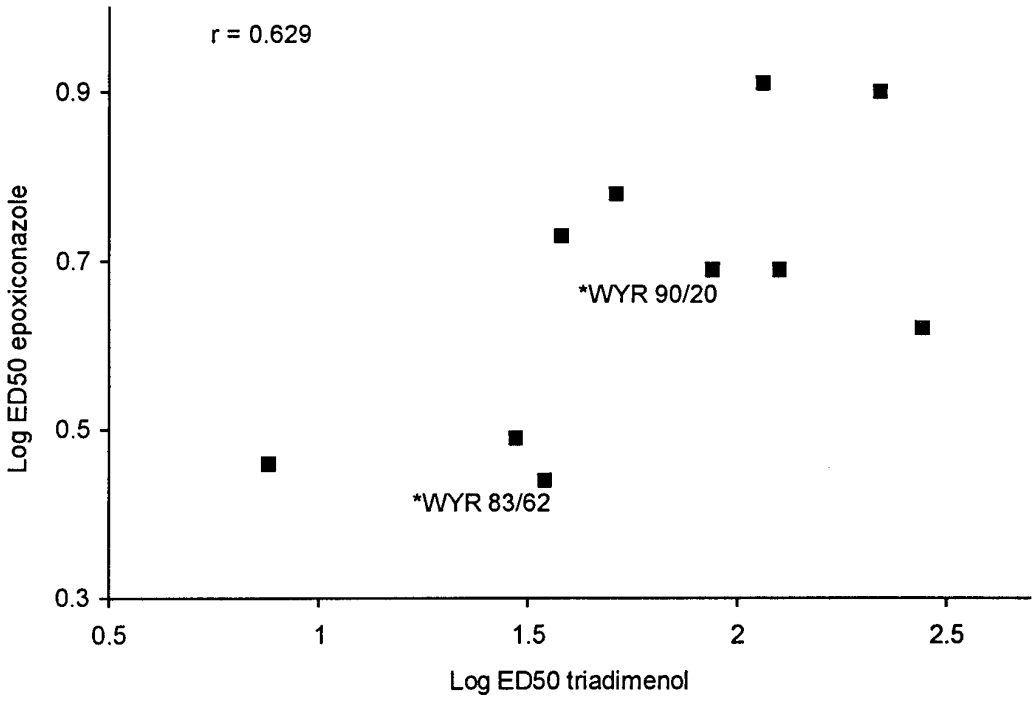
* Reference isolates from survey of 1960-1990 isolates
WYR 83/62 - from middle of sensitivity range
WYR 90/20 - from insensitive end of range

Figure 2. Frequency distribution of 'D' values for insensitivity to triadimenol for 291 isolates of *Puccinia striiformis* collected between 1960 and 1990 (from Barnard, 1992)



* Reference isolates maintained for future comparisons
WYR 83/62 - from middle of sensitivity range
WYR 90/20 - from insensitive end of range

Figure 3. Relationship between Log ED50 values for triadimenol and epoxiconazole



* Reference isolates from survey of 1960-1990 isolates
WYR 83/62 - from middle of sensitivity range
WYR 90/20 - from insensitive end of range